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(54) Block polyesters and like compounds useful as soil release agents in detergent compositions.

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Description

Technical Field

The present application relates to block polyesters and like compounds useful as soil release agents in laundry detergent compositions.

In addition to cleaning performance, laundry detergent compositions desirably have other benefits. One is the ability to confer soil release properties to fabrics woven from polyester fibers. These fabrics are mostly co-polymers of ethylene glycol and terephthalic acid, and are sold under a number of tradenames, e.g. Dacron, Fortrel, Kodel and Blue C Polyester. The hydrophobic character of polyester fabrics makes their laundering difficult, particularly as regards, oily soil and oily stains. The oily soil or stain preferentially "wets" the fabric. As a result, the oily soil or stain is difficult to remove in an aqueous laundering process.

High molecular weight (e.g., 40,000 to 50,000 M.W.) polyesters containing random ethylene terephthalate/polyethylene glycol (PEG) terephthalate units have been used as soil release compounds in laundry detergent compositions. See U.S.-A-3,962,152 to Nicol et al., issued June 8, 1976. During the laundering operation, these soil release polyesters adsorb onto the surface of fabrics immersed in the wash solution. The adsorbed polyester then forms a hydrophilic film which remains on the fabric after it is removed from the wash solution and dried. This film can be renewed by subsequent washing of the fabric with a detergent composition containing the soil release polyesters.

These ethylene terephthalate/PEG terephthalate polyesters are not very water-soluble. It is believed that they form a suspension in the wash solution which does not adsorb efficiently onto the fabrics. As a result, the level of soil release polyester in the detergent composition has to be increased if benefits are to be obtained after several wash cycles. Because of this poor water-solubility, these polyesters are formulated as suspensions in laundry detergent compositions, rather than as isotropic liquids. In certain detergent formulations, these polyesters can also diminish clay soil cleaning performance.

Background Art

A. Polyester anti-static agents formed from dimethyl terephthalate, ethlene glycol and methoxy PEGs.

U.S.-A- 3,416,952 to McIntyre et al., issued December 17, 1968, discloses the treatment of shaped polyester articles with a water-insoluble crystallizable polymeric compound which can contain a water-solvatable polymeric group such as a polyoxyalkylene group having an average molecular weight of from 300-6000. Preferred polyoxyalkylene groups are the PEGs having an average molecular weight of from 1000-4000. Treatment of the shaped articles is carried out by applying an aqueous dispersion of the crystallizable polymeric compound in the presence of an anti-oxidant, followed by heating to a temperature above 90°C to obtain a durable coating of the compound on the shaped article. Example 6 discloses one such crystallizable polymeric compound formed by the reaction of dimethyl terephthalate, ethylene glycol and an O-methyl poly(oxyethylene) glycol of average molecular weight 350. A 20% solution of this polyester in benzyl alcohol was used to impart anti-static properties to a polyester fabric. Example 7 discloses a 20% aqueous solution of a similar polyester used to impart anti-static properties to a polyester fabric.

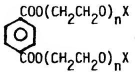
B. Polyester anti-static and soil release agents formed from dimethyl terephthalate, sodium dimethyl 5-sulphoisophthalate, ethylene glycol and polyethylene glycol (PEG)

U.S.-A- 4,427,557 to Stockburger, filed February 15, 1983, issued January 24, 1984, discloses low molecular weight copolyesters (M.W. 2,000 to 10,000) which can be used in aqueous dispersions to impart soil release properties to polyester fibers. The copolyesters are formed by the reaction of ethylene glycol, a PEG having an average molecular weight of 200 to 1000, an aromatic dicarboxylic acid (e.g. dimethyl terephthalate), and a sulfonated aromatic dicarboxylic acid (e.g. dimethyl 5-sulfoisophthalate). The PEG can be replaced in part with monoalkylethers of PEG such as the methyl, ethyl and butyl ethers. A dispersion or solution of the copolyester is applied to the textile material and then heat set at elevated temperatures (90° to 150°C) to impart durable soil release properties.

C. Monomeric polyesters of PEG and terephthalic acid useful as soil release agents

U.S.-A- 4,349,688 to Sandler, issued September 14, 1982, discloses polyoxyalkylene ester soil release

agents, in particular monomeric polyesters of PEG and terephthalic acid having the formula:



where n can range from 6-23 and X is either methyl or H. Example IV discloses the preparation of one such PEG/terephthalate polyester formed from terephthaloyl chloride and Carbowax 400 (n = 9, X = H). Durable soil resistancy and water wicking properties are imparted by wetting the fabric with a composition containing the polyoxyalkylene ester, drying the wetted fabric, and then curing the dried fabric at a temperature of from 190°-200°C for about 45-90 seconds.

D. Ethylene terephthalate/PEG terephthalate soil release polyesters for fabric treating solutions.

U.S.-A- 3,959,230 to Hays, issued May 25, 1976, discloses polyester soil release agents containing random ethylene terephthalate/PEG terephthalate units in a mole ratio of from about 25:75 to about 35:65. These soil release polyesters have a molecular weight of from about 25,000 to about 55,000, (preferably from about 40,000 to about 55,000) and are used in dilute, aqueous solutions, preferably with an emulsifying agent present. Fabrics are immersed in this solution so that the soil release polyester adsorbs onto the fabric surface. The polyester forms a hydrophilic film which remains on the fibers after the fabric is removed from the solution and dried. See also U.S. 3,893,929 to Basadur, issued July 8, 1975 (compositions for imparting soil release finish containing a polyester having an average molecular weight of 3000-5000 formed from terephthalic acid, PEG and ethylene glycol); U.S.-A- 3,712,873 to Zenk, issued January 23, 1973 (textile treating composition comprising fatty alcohol polyethoxylates; quaternary ammonium compounds; a polyester having average molecular weight of 3000-5000 formed from terephthalic acid, PEG and ethylene glycol; and starch).

E. Ethylene terephthalate/PEG terephthalate soil release agents used in detergent compositions.

U.S.-A- 3,962,152 to Nicol et al., issued June 8, 1976, discloses detergent compositions containing detergent surfactants and the ethylene terephthalate/PEG terephthalate soil release polyesters disclosed in the Hays patent. See also U.S.-A-4,116,885 to Derstadt et al., issued September 26, 1978 (detergent compositions containing certain compatible anionic detergent surfactants and ethylene terephthalate/PEG terephthalate soil release polyesters); U.S.-A- 4,132,680 to Nicol, issued January 2, 1979 (detergent compositions containing detergent surfactants; a composition which disassociates to yield quaternary ammonium cations; and an ethylene terephthalate/PEG terephthalate soil release polyester).

F. Soil release and antistatic polyurethanes useful in detergent compositions which contain polyester blocks having sulfoisophthalate units.

U.S.-A- 4,201,824 to Violland et al., issued May 6, 1980, discloses hydrophilic polyurethanes having soil release and antistatic properties useful in detergent compositions. These polyurethanes are formed from the reaction product of a base polyester with an isocyanate prepolymer (reaction product of diisocyanate and macrodiol). Example VI discloses a base polyester formed from dimethyl terephthalate, dimethyl sulfoisophthalate, ethylene glycol and PEG (molecular weight 300) which is reacted with a prepolymer formed from a PEG (molecular weight 1,500) and toluene diisocyanate.

DISCLOSURE OF THE INVENTION

The present invention relates to compounds of formula:

$$X\text{-}(OCH_2CH_2)_n\text{-}[\text{-}(\text{-}\overset{O}{\overset{\|}{C}}O\text{-}R^1\text{-}\overset{O}{\overset{\|}{C}}O\text{-}R^2\text{-})\text{-}]_u\text{-}O\overset{O}{\overset{\|}{C}}\text{-}R^1\text{-}\overset{O}{\overset{\|}{C}}O\text{-}(CH_2CH_2O)_n\text{-}X$$

wherein each R^1 is a 1,4-phenylene moiety; the R^2 consist essentially of ethylene moieties, 1,2-propylene moieties or a mixture thereof; each X is ethyl or preferably methyl; each n is from 12 to 43; u is from 3 to 10.

The present invention further relates to detergent compositions, especially for laundry use, which comprise a soil release component having an effective amount of these compounds. These detergent compositions further comprise from 1 to 75% by weight of a nonionic, anionic, ampholytic, zwitterionic, or cationic detergent surfactant, or mixture thereof. In addition to these detergent surfactants, the detergent compositions can optionally comprise from 0 to 60% by weight of a detergent builder.

The compounds of the present invention provide excellent soil release benefits to polyester fabrics during laundering, but without diminishing the clay soil cleaning performance of the detergent composition. These compounds can be used at lower levels in detergent compositions to provide soil release benefits at least equivalent to prior art high molecular weight ethylene terephthalate/PEG terephthalate polyesters. Some of the compounds of the present invention can also be formulated to provide isotropic liquid detergent compositions.

Certain of the soil release compounds of the present invention provide additional through-the-wash static control benefits to laundered fabrics. The compounds of the present invention also provide cleaning benefits in terms of greasy/oily stain removal, as well as whiteness maintenance benefits. In addition, it is expected that the soil release compounds of the present invention will be more biodegradable than prior art ethylene terephthalate/PEG terephthalate soil release polyesters.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 shows a ^{13}C-NMR spectrum of block polyester compounds of the present invention.

Figure 2 shows an enlarged view of a portion of the ^{13}C-NMR spectrum shown in Figure 1.

Soil Release Compounds

$$X\text{-}(OCH_2CH_2)_n\text{—}[\text{-}(O\overset{O}{\overset{\|}{C}}\text{-}\ R^1\ \text{-}\overset{O}{\overset{\|}{C}}O\text{-}R^2)\ \text{-}]_u\text{-}O\overset{O}{\overset{\|}{C}}\text{-}R^1\ \text{-}\overset{O}{\overset{\|}{C}}O\text{-}(CH_2CH_2O)_n\text{-}X$$

In this formula, the moiety

$$\text{—}[\text{-}(O\overset{O}{\overset{\|}{C}}\text{-}\ R^1\ \text{-}\overset{O}{\overset{\|}{C}}O\text{-}R^2)\ \text{-}]_u$$

forms the oligomer or polymer backbone of the compounds. It is believed that the structure of the backbone is what is important to the adsorption of the compounds on polyester fabrics during laundering. Groups X{-$(OCH_2CH_2)_n$ and $(CH_2CH_2O)_n$}Xare generally connected at the ends of the oligomer/polymer backbone. It is believed that the soil release properties of the compounds (when absorbed on the fabric) are due to these hydrophilic end groups.

The R^1 moieties are essentially 1,4-phenylene moieties. As used herein, the term "the R^1 moieties are essentially 1,4-phenylene moieties" refers to compounds where the R^1 moieties consist entirely of 1,4-

phenylene moieties, or are partially substituted with other arylene or alkarylene moieties, alkylene moieties, alkenylene moieties, or mixtures thereof. Arylene and alkarylene moieties which can be partially substituted for 1,4-phenylene include 1,3-phenylene, 1,2-phenylene, 1,8-naphthylene, 1,4-naphthylene, 2,2'-biphenylene, 4,4'-biphenylene and mixtures thereof. Alkylene and alkenylene moieties which can be partially substituted include ethylene, 1,2-propylene, 1,4-butylene, 1,5-pentylene, 1,6-hexamethylene, 1,7-heptamethylene, 1,8-octamethylene, 1,4-cyclohexylene, and mixtures thereof.

For the R^1 moieties, the degree of partial substitution with moieties other than 1,4-phenylene should be such that the soil release properties of the compound are not adversely affected to any great extent. Generally, the degree of partial substitution which can be tolerated will depend upon the backbone length of the compound, i.e., longer backbones can have greater partial substitution for 1,4-phenylene moieties. Usually, compounds where the R^1 comprise from 50 to 100% 1,4-phenylene moieties (from 0 to 50% moieties other than 1,4-phenylene) have adequate soil release activity. For example, polyesters made according to the present invention with a 40:60 mole ratio of isophthalic (1,3-phenylene) to terephthalic (1,4-phenylene) acid have adequate soil release activity. However, because most polyesters used in fiber making comprise ethylene terephthalate units, it is usually desirable to minimize the degree of partial substitution with moieties other than 1,4-phenylene for best soil release activity. Preferably, the R^1 moieties consist entirely of (i.e., comprise 100%) 1,4-phenylene moieties, i.e. each R^1 moiety is 1,4-phenylene.

The R^2 moieties are essentially ethylene moieties, or substituted ethylene moieties having C_1-C_4 alkyl or alkoxy substitutents. As used herein, the term "the R^2 moieties are essentially ethylene moieties, or substituted ethylene moieties having C_1-C_4 alkyl or alkoxy substituents" refers to compounds of the present invention where the R^2 moieties consist entirely of ethylene, or substituted ethylene moieties, or are partially substituted with other compatible moieties. Examples of these other moieties include linear C_3-C_6 alkylene moieties such as 1,3-propylene, 1,4-butylene, 1,5-pentylene or 1,6-hexamethylene, 1,2-cycloalkylene moieties such as 1,2-cyclohexylene, 1,4-cycloalkylene moieties such as 1,4-cyclohexylene and 1,4-dimethylenecyclohexylene, polyoxyalkylated 1,2-hydroxyalkylenes such as

$$\begin{array}{l} -CH_2-\underset{|}{C}H- \ , \\ \qquad\quad CH_2-O(CH_2CH_2O)_n-X \end{array}$$

and oxyalkylene moieties such as $-CH_2CH_2OCH_2CH_2OCH_2CH_2-$ or $-CH_2CH_2OCH_2CH_2-$.

For the R^2 moieties, the degree of partial substitution with these other moieties should be such that the soil release properties of the compounds are not adversely affected to any great extent. Generally, the degree of partial substitution which can be tolerated will depend upon the backbone length of the compound, i.e., longer backbones can have greater partial substitution. Usually, compounds where the R^2 comprise from t 20 to 100% ethylene, or substituted ethylene moieties (from 0 to 80% other compatible moieties) have adequate soil release activity. For example, for polyesters made according to the present invention with a 75:25 mole ratio of diethylene glycol ($-CH_2CH_2OCH_2CH_2-$) to ethylene glycol (ethylene) have adequate soil release activity. However, it is desirable to minimize such partial substitution, especially with oxyalkylene moieties, for best soil release activity. (During the making of polyesters according to the present invention, small amounts of these oxyalkylene moieties (as dialkylene glycols) are typically formed from glycols in side reactions and are then incorporated into the polyester). Preferably, R^2 comprises from 80 to 100% ethylene, or substituted ethylene moieties, and from 0 to about 20% other compatible moieties.

For the R^2 moieties, suitable ethylene or substituted ethylene moieties include ethylene, 1,2-propylene, 1,2-butylene, 1,2-hexylene, 3-methoxy-1,2-propylene and mixtures thereof. Preferably, the R^2 moieties are essentially ethylene moieties, 1,2-propylene moieties or mixtures thereof. Inclusion of a greater percentage of ethylene moieties tends to improve the soil release activity of the compounds. Surprisingly, inclusion of a greater percentage of 1,2-propylene moieties tends to improve the water solubility of the compounds. X is methyl or ethyl, and most preferably methyl.

The value for each n is at least about 6, but is preferably at least 10. Typically, the value for each n is in the range of from 12 to 43.

It has been found that the value of u needs to be at least 3 in order for the compounds of the present invention to have significant soil release activity. The compounds of the present invention are oligomers or low molecular weight polymers. Typically, the value of u ranges from 3 to 10 for the compounds of the present invention.

Generally, the larger the u value, the less soluble is the compound, Also, as the value for n increases,

the value for u should be increased so that the compound will deposit better on the fabric during laundering.

Preferred compounds of the present invention are block polyesters having the formula:

$$X-(OCH_2CH_2)_n-[-(O\overset{\displaystyle O}{\overset{\|}{C}}-R^1-\overset{\displaystyle O}{\overset{\|}{C}}O-R^2)_u]-\;-O\overset{\displaystyle O}{\overset{\|}{C}}-R^1-\overset{\displaystyle O}{\overset{\|}{C}}O-(CH_2CH_2O)_n-X$$

wherein the R^1 moieties are all 1,4-phenylene moieties; the R^2 moieties are essentially ethylene moieties, 1,2-propylene moieties or mixtures thereof; each X is ethyl or preferably methyl; each n is from 12 to 43; u is from 3 to 10; u typically ranges from 3 to 8, especially for those polymers from dimethyl terephthalate, ethylene glycol (or 1,2-propylene glycol) and methyl capped polyethylene glycol. The most water soluble of these linear block polyesters are those where u is from 3 to 5.

Method for Making Compounds

The compounds of the present invention can be prepared by art-recognized methods. Although the following synthesis description is for the preferred block polyesters of the present invention, other versions can be prepared by appropriate variation.

The block polyesters of the present invention are typically formed from: (1) ethylene glycol, 1,2-propylene glycol or a mixture thereof; (2) a polyethylene glycol (PEG) capped at one end with a C_1-C_4 alkyl group; (3) a dicarboxylic acid (or its diester); The respective amounts of these components are selected to prepare polyesters having the desired properties in terms of solubility and soil release properties.

The capped PEG used to prepare polyesters of the present invention is typically methyl capped and can be formed by ethoxylation of the respective alcohol with ethylene oxide. Also, methyl capped PEGs are commercially available from Union Carbide under the trade name Methoxy Carbowax and from Aldrich Chemical Company under the name poly(ethylene glycol) methyl ether. These commercial methyl capped PEGs have molecular weights of, 550 (n = about 12), 750 (n = about 16), 1900 (n = about 43),

Terephthalic acid or its diester is the major dicarboxylic acid present. However, minor amounts of other aromatic dicarboxylic acids (or their diesters), or aliphatic dicarboxylic acids (or their diesters) can be included to the extent that the soil release properties are substantially maintained. Illustrative examples of other aromatic dicarboxylic acids which can be used include isophthalic acid, phthalic acid, naphthalene dicarboxylic acids, anthracene dicarboxylic acids, biphenyl dicarboxylic acids, oxydibenzoic acids and the like, as well as mixtures of these acids. If aliphatic dicarboxylic acids are included, adipic, glutaric, succinic, trimethyladipic, pimelic, azelaic, sebacic, suberic, 1,4-cyclohexane dicarboxylic acid and/or dodecanedioic acids can be used.

The preferred method for preparing block polyesters of the present invention comprises reacting the desired mixture of lower dialkyl esters (methyl, ethyl, propyl or butyl) of the dicarboxylic acid with a mixture of the glycol (ethylene glycol, 1,2-propylene glycol or a mixture thereof) and the capped PEG. The glycol esters and oligomers produced in this ester interchange reaction are then polymerized to the desired degree. The ester interchange reaction can be conducted in accordance with reaction conditions generally used for ester interchange reactions. This ester interchange reaction is usually conducted at temperatures of from 120° to 220°C in the presence of an esterification catalyst. Alcohol is formed and constantly removed thus forcing the reaction to completion. The temperature and pressure of the reaction are desirably controlled so that glycol does not distill from the reaction mixture. Higher temperatures can be used if the reaction is conducted under pressure.

The catalysts used for the ester interchange reaction are those well known to the art. These catalysts include alkyl and alkaline earth metals, for example lithium, sodium, calcium, and magnesium, as well as transition and Group II B metals, for example antimony, maganese, cobalt, and zinc, usually as the respective oxides, carbonates, or acetates. Typically, antimony trioxide and calcium acetate are used.

The extent of the ester interchange reaction can be monitored by the amount of alcohol liberated or the disappearance of the dialkyl esters of the dibasic acids in the reaction mixture as determined by high performance liquid chromatography (HPLC) or any other suitable method. The ester interchange reaction is desirably taken to more than 90% completion. Greater than 95% completion is preferred in order to decrease the amount of sublimates obtained in the polymerization step.

If desired, stabilizers such as phosphorus and phosphoric acid and esters thereof can be added at the

end of the ester interchange step. The purpose of the stabilizier is to inhibit degradation, oxidation, and other side reactions; to destroy the catalytic activity of the ester interchange catalyst; and to prevent precipitation of insoluble metal carboxylates. Typically, stabilizers are not used to make the polyesters of the present invention.

When the ester interchange reaction is complete, the glycol ester products are then polymerized to produce polyesters. The desired degree of polymerization can be determined by HPLC and ^{13}C-NMR analysis. For commercial processes, the polymerization reaction is usually conducted at temperatures of from 200° to 280°C in the presence of a catalyst. Higher temperatures can be used but tend to produce darker colored products. Illustrative examples of catalysts useful for the polymerization step include antimony trioxide, germanium dioxide, titanium alkoxide, hydrated antimony pentoxide, and ester interchange catalysts such the as salts of zinc, cobalt, and maganese.

Excess glycol and other volatiles liberated during the reaction are removed under vacuum. The reaction is continued until polymerization is nearly complete based on analysis by ^{13}C-NMR and/or reverse phase HPLC and/or gel phase permeation. In addition to the desired polyesters, the crude composition obtained after synthesis contains starting reactants, as well as intermediate products.

Representative examples of specific block polyesters formed according to the present invention are as follows:

EXAMPLE 1

A linear block polyester made from dimethyl terephthalate, a methyl capped PEG and ethylene glycol was synthesized as follows:

The following reactants and catalysts were placed in a three necked, 2 liter round bottom flask:

1. poly(ethylene glycol) methyl ether, M.W. 750, Aldrich Chemical Co., 1000 g (1.33 moles)
2. dimethyl terephthalate, Aldrich Chemical Co., 359.9 g (1.85 moles)
3. ethylene glycol, Matheson Coleman Bell (MCB), 140 g (2.26 moles)
4. calcium acetate monohydrate, MCB, 2 g
5. antimony trioxide, Fisher, 2 g

A 0.9 g portion of butylated hydroxytoluene (BHT) was added to the reactants as an antioxidant and the reaction system was then equipped for distillation through a 10.16 cm (4 inch) unpacked column. The system was placed under a nitrogen atmosphere and the temperature was raised to 175°C gradually in about 2 hrs with magnetic stirring once the reaction mixture melted. When methanol began to distill, the temperature was then raised to 205°C during the next 5 hrs. At this point, about 70% of the theoretical amount of methanol had distilled out. The temperature was then raised to 220°C and held at this temperature for the next 18 hrs. to give 93% of the theoretical amount of methanol.

The receiving flask was then emptied and the reaction mixture cooled to 130°C. A vacuum was then applied with a steady flow of nitrogen being introduced below the level of the liquid reaction mixture through a fritted glass inlet. The temperature was gradually raised to 200°C and the vacuum held at 2.6 10^{-3} atm (20 mm Hg.) After approximately 15 hrs. at 200°C (under vacuum), the reaction was essentially complete as indicated by ^{13}C-NMR which showed only trace quantities of residual $-CH_2OH$ groups. Reverse phase HPLC analysis using a column packed with hexyl capped silica particles and an acetonitrile/water gradient elution showed a sizeable part of the polymer contained 4 or more terephthalate units per molecule. By appropriate variation of reaction conditions, similar polyesters can be prepared by substituting 1,2-propylene glycol for ethylene glycol.

Example 2

A linear block polyester made from terephthalic acid, a methyl capped PEG and ethylene glycol was synthesized as follows:

Twenty grams (0.12 moles) of terephthalic acid and 22.4 g (0.36 moles) of ethylene glycol (MCB) were heated together at 220°-240°C in a short path distillation apparatus. Ethylene glycol which distilled out with the water was periodically replaced. After 13 hrs. of heating, the reaction mixture was cooled and the following were added:

1. poly (ethylene glycol) methyl ether, M.W. 750 (Aldrich), 102.6 g (0.137 moles)
2. antimony trioxide (Fisher), 0.50 g
3. calcium acetate monohydrate (MCB), 0.50 g
4. BHT (Aldrich), 0.20 g

The reaction system was gradually heated to 240°C with little distillate in evidence. A vacuum was then

applied and the temperature was held at 240°-250°C for 6 hrs. to give the desired polyester. Gel permeation chromatography indicated the apparent peak molecular weight was approximately 2200 relative to several polystyrene standards.

Method for Determining Degree of Polymerization

A method for determining the degree of polymerization of the polyesters of the present invention involves: (1) alcohol fractionation of the crude polyester composition obtained after synthesis; (2) high performance liquid chromatographic (HPLC) separation of the methanol soluble fraction to yield additional fractions; and (3) ^{13}C-NMR analysis to determine backbone length (i.e. value for u) of the polyesters present in each of the various HPLC fractions. While this method is described with respect to polyesters made from terephthalic acid and ethylene glycol, it should be suitable, with appropriate modifications, for analyzing other polyester versions of the present invention.

A. Alcohol Fractionation

The crude polyester composition obtained after synthesis is successively extracted with 2-propanol, ethanol and methanol to obtain a methanol soluble fraction which contains more of the desired active polyesters. One such fractionation was carried out as follows:

A 569 g portion of a crude polyester composition made similar to Example 1 was melted and poured into a 4 liter Erlenmeyer flask. After the crude polyester had cooled, 2000 ml of 2-propanol was added. This mixture was stirred for about 60 hrs. The dispersion was allowed to settle and the clear supernatant was decanted. The residue was stirred again with another 2000 ml of 2-propanol. All remaining lumps of polyester were broken up. After stirring 2 hrs, the solids were allowed to settle and the clear supernatant was decanted. Then a third 2000 ml portion of 2-propanol was added to the precipitate and this mixture was stirred overnight. The resulting dispersion was allowed to settle. The supernatant was decanted and the residue was centrifuged to remove as much 2-propanol as possible. The residue was then taken up in 3000 ml of 3A denatured ethanol. This dispersion was stirred overnight at room temperature. It was then centrifuged to give a slightly cloudy supernatant which was decanted. The precipitate was dispersed in 3250 ml of methanol by stirring overnight at room temperature. Centrifugation gave a cloudy supernatant. This supernatant containing the methanol soluble polyesters was decanted and the methanol was removed on a rotary evaporator followed by 15 minutes on an Aldrich kugelrohr at 110°C. This yielded 98.5 grams of a methanol soluble fraction (17.5%) of polyesters.

B. Semi-Preparative HPLC Fractionation

The crude polyester compositions of the present invention, such as those of Example 1, can be separated into various, identifiable fractions by HPLC. Typically, a chromatogram for identifying the various fractions of the crude polyester composition is developed using the following HPLC conditions:

1. Equipment:
   a. Waters WISP 710B automatic injector
   b. Two Laboratory Data Control (LDC) Model III pumps
   c. LDC Gradient Master
   d. LDC Spectromonitor III detector
   e. Waters Data Module Model 730 recorder
2. Solvent Program:
   a. initial conditions: 34% CH_3CN/66% H_2O
   b. final conditions: 60% CH_3CN/40% H_2O
   c. gradient time: 20 min., then 15 min. hold at final conditions
   d. linear gradient
   e. flow rate: 1 ml/min
3. Column: 4.6 mm x 25 cm. Phase Separations' Spherisorb 5 micron hexyl
4. Injection Volume: 10-50 microl.
5. Detection: 254 nm uv at 0.1-0.3 Absorbance Units Full Scale (AUFS)
6. Sample Preparation: 1.0-4.0 mg/ml predissolved in 34% CH_3CN/66%H_2O

Some of the peaks present in this crude chromatogram represent fractions of the polyester composition which contain little or none of the active soil release polyesters. Accordingly, a semi-preparative HPLC procedure is used to obtain fractions containing more of the active polyesters for subsequent ^{13}C-NMR

analysis. This semi-preparative method involves separating the previously obtained methanol soluble fraction by HPLC into additional fractions using the following conditions:

1. Equipment:
   a. Rheodyne 7126 valve manual injector
   b. Two Perkin/Elmer System III pumps
   c. Micromeritics 788 detector
   d. Sargent Welch strip chart recorder
2. Solvent Program:
   a. initial conditions: 38% CH_3CN/62% H_2O
   b. step 1: final conditions, 55% CH_3CN/45% H_2O, linear gradient, 22.7 min.
   c. step 2: 55% CH_3CN/45% H_2O, hold for 7 min.
   d. step 3: final conditions, 75% CH_3CN/25% H_2O, linear gradient, 23.5 min.
   e. step 4: 75% CH_3CN/25% H_2O, hold for 7 min.
   f. flow rate: 20 ml/min.
3. Column: 20 mm x 25 cm. Phase Separations Spherisorb 5 micron hexyl
4. Injection Volume: 3.8 ml.
5. Detection: 254 nm uv at 0.6-2.56 AUFS
6. Sample Preparation: saturated solution in 38% CH_3CN/62% H_2O

The fractions obtained by semi-preparative HPLC are compared to those of the chromatogram for the crude composition to identify the various fractions. A representatiave semi-preparative HPLC fractionation of a polyester composition made similar to Example 1 is shown in the following Table:

Fraction	Retention Time (min)*
I	12.0
II	16.0
III	18.4
IV	20.9
V	22.9
VI	24.6
VI	26.3
VI	28.1

* From HPLC analysis of unfractionated crude polyester composition.

C. ^{13}C-NMR Analysis

The various fractions obtained by semi-preparative HPLC can be analyzed by ^{13}C-NMR to determine the degree of polymerization of the polyesters present in each fraction. Figure 1 represents a ^{13}C-NMR spectrum of a polyester composition made similar to Example 1. Figure 2 represents an expanded view of a portion of the spectrum shown in Figure 1.

Assignment of carbon resonances are made by comparison to model compounds and/or spiking experiments. ^{13}C-NMR parameters are chosen to give quantitative information, i.e., peak areas can be used to determine relative levels of intermediate compounds and polyesters present in the semi-preparative HPLC fraction.

Chemical shift assignments of several key carbon resonances are shown in the following Table:

Carbon Resonance	Chemical Shift (ppm)
Carbon of Methyl Cap (X group)	57.8
Carbons of Ethylene (R^2 moiety)	61.8
2,3,5,6 Carbons of Terephthalate (R^1 moiety)	128.4
1,4 Carbons of Terephthalate (R^1 moiety)	132.2-133.0

There are two ways to express the average degree of polymerization of the polyesters present in each fraction. The first is a ratio of areas (determined by ^{13}C-NMR) of the ethylene units (S) present in the

polyester backbone relative to the methyl cap (M) of the PEG. This ratio S/M is equal to Area 3 (see Figure 1) divided by Area 1 (see Figure 1), which is then multiplied by 1/2. The second is a ratio of the average number of aromatic terephthalate units (A) present in the backbone relative to M. This second ratio A/M equals Area 2 (see Figure 1) divided by Area 1, which is then multiplied by 1/4.

A more useful quantity is obtained by adjusting the observed A/M ratio for the contribution of monoterephthalate polyesters, i.e. where u is 0.

The adjusted A/M value equals

$$\frac{A/M - (0.5)\ f_1}{1 - f_1}$$

wherein f_1 is the mole fraction of monoterephthalate polyester (area f_1/Total Area, see Figure 2). Another important value is f_4 which represents the mole fraction of terephthalate present in polyesters having 3 or more terephthalate units (Area f_4/Total Area, see Figure 2).

The results of ^{13}C-NMR analysis of the fractions obtained by semi-preparative HPLC of a polyester composition made similar to Example 1 is shown in the following Table:

Fraction	f_1	f_4	A/M	Adjusted A/M	S/M
I	0.9	0.05	0.67	-	0.14
II	0.12	0.09	0.95	1.02	0.34
III	0.09	0.31	1.30	1.38	0.70
IV	0.09	0.43	1.87	2.01	1.16
V	0.13	0.46	2.43	2.71	1.61
VI	0.13	0.49	3.92	4.41	2.31

Twice the S/M ratio equals the average number of ethylene units for the polyesters present in the fraction. Twice the adjusted A/M ratio equals the average number of terephthalate units (u + 1) for the polyesters present in the fraction. By using these values, the qualitative composition of the polyester fraction in terms of backbone length (u) can be determined.

DETERGENT COMPOSITIONS

Soil Release Component

The compounds of the present invention are particularly useful in detergent compositions to provide soil release properties. These compositions can be used as laundry detergents, laundry additives, and laundry pre-treatments.

The detergent compositions of the present invention comprise a soil release component which contains an effective amount of the soil release compounds previously defined. What is an "effective amount" will depend upon the particular soil release compounds used, the particular type of detergent formulation (liquid, granular, etc.) and the benefits desired. Usually, the soil release compounds are effective when included in an amount from about 0.01 to about 10% by weight of the composition. In terms of soil release benefits, preferred detergent compositions can comprise from about 0.1 to about 5% by weight of the soil release compounds, but typically comprise from about 0.3 to about 3% by weight of these compounds.

For granular detergent formulations, the soil release component typically comprises the soil release compounds, plus any protective enrobing material. In making granular detergent formulations, the soil release compounds could be exposed to highly alkaline materials such as NaOH and KOH. The soil release compounds, in particular those having shorter backbones, can be degraded by alkaline environments, especially those above a pH of about 8.5. Accordingly, the soil release compounds are preferably enrobed in a material which protects them from the alkaline environment of a granular detergent formulation yet permits the soil release compounds to be dispersed in the laundering operation.

Suitable enrobing materials include the nonionic surfactants, polyethylene glycols (PEG), fatty acids, fatty acid esters of alcohols, diols and polyols, anionic surfactants, film forming polymers and mixtures of these materials. Examples of suitable nonionic surfactant enrobing materials are described in the Detergent Surfactant section of this application. Examples of suitable PEG enrobing materials are those having an

average M.W. of from about 2,000 to 15,000, preferably from 3,000 to 10,000 and most preferably from 4,000 to 8,000. Examples of suitable fatty acid enrobing materials are the higher fatty acids having from 12 to 18 carbon atoms. Examples of suitable fatty acid ester enrobing materials include the sorbitan fatty acid esters (e.g. sorbitan monolaurate). Other examples of suitable enrobing materials, including anionic surfactants and film forming polymers, are disclosed in U.S.-A- 4,486,327 to Murphy et al., issued December 4, 1984,. The soil release compounds can be enrobed according to the methods disclosed in this Murphy et al. patent.

For liquid detergent formulations, the soil release component can be comprised entirely of soil release compounds or can further include a water-soluble organic solvent or an hydrotrope to aid in dissolving the soil release compounds. Suitable organic solvents are usually aromatic and can include ethyl benzoate, phenoxyethanol, methyl-o-toluate, 2-methoxybenzyl alcohol and pyrrolidone. Suitable hydrotropes include the methyl capped PEGs and shorter backbone block polyesters, i.e. where u is 0 to 2. While these short backbone block polyesters do not have any significant soil release activity, they are water-soluble. Accordingly, these short backbone polyesters function as hydrotropes for the longer backbone, water-insoluble polyesters which have soil release activity.

The amount, or even need for, organic solvents or hydrotropes to prepare liquid detergent formulations containing the soil release compounds of the present invention will depend upon the compounds used, especially what fraction thereof is water-soluble, the ingredients present in the laundry detergent system, and whether an isotropic, homogeneous liquid is desired. For isotropic liquid detergent formulations, the soil release compounds need to be dissolved as much as possible which sometimes requires the use of organic solvents or hydrotropes. Also, it has been found that dissolving the compounds in the liquid detergent formulations makes them more effective as soil release agents.

Besides organic solvents or hydrotropes, greater amounts of water-soluble soil release compounds can be included in the soil release component to aid in the preparation of isotropic liquid detergent formulations. For example, soil release polyesters with backbones having from 3 to 5 ($u = 3$ to 5) ethylene terephthalate units and having a methyl capped PEG of molecular weight of 750 ($n =$ about 16) at each end are water-soluble. In addition, soil release polyesters prepared from dimethyl terephthalate, ethylene glycol and methyl capped PEGs typically contain a substantial fraction of water-soluble polyesters (both active and inactive types) which aid in dissolving water-insoluble soil release polyesters in the liquid detergent formulation. Partial or total substitution of 1,2-propylene glycol for ethylene glycol can also be used to increase the solubility of the soil release polyesters. The more water-soluble 1,2-propylene glycol based soil release polyesters are particularly useful in making isotropic liquid detergent formulations which have a large number of ingredients and low water content.

Detergent Surfactants

The amount of detergent surfactant included in the detergent compositions of the present invention can vary from 1 to 75% by weight of the composition depending upon the detergent surfactant(s) used, the type of composition to be formulated (e.g. granular, liquid) and the effects desired. Preferably, the detergent surfactant(s) comprises from 10 to 50% by weight of the composition, and most preferably from 15 to 40% by weight. The detergent surfactant can be nonionic, anionic, ampholytic, zwitterionic, cationic, or a mixture thereof:

A. Nonionic Surfactants

Suitable nonionic surfactants for use in detergent compositions of the present invention are generally disclosed in U.S. 3,929,678 to Laughlin et al., issued December 30, 1975 at column 13, line 14 through column 16, line 6.

Classes of nonionic surfactants included are:

1. The polyethylene oxide condensates of alkyl phenols. These compounds include the condensation products of alkyl phenols having an alkyl group containing from 6 to 12 carbon atoms in either a straight chain or branched chain configuration with ethylene oxide, the ethylene oxide being present in an amount equal to 5 to 25 moles of ethylene oxide per mole of alkyl phenol. The alkyl substituent in such compounds can be derived, for example, from polymerized propylene, and diisobutylene. Examples of compounds of this type include nonyl phenol condensed with about 9.5 moles of ethylene oxide per mole of nonyl phenol; dodecylphenol condensed with about 12 moles of ethylene oxide per mole of phenol; dinonyl phenol condensed with about 15 moles of ethylene oxide per mole of phenol; and diisooctyl phenol condensed with about 15 moles of ethylene oxide per mole of phenol. Commercially

available nonionic surfactants of this type include Igepal CO-630, marketed by the GAF Corporation, and Triton X-45, X-114, X-100, and X-102, all marketed by the Rohm & Haas Company.

2. The condensation products of aliphatic alcohols with from 1 to 25 moles of ethylene oxide. The alkyl chain of the aliphatic alcohol can either be straight or branched, primary or secondary, and generally contains from 8 to 22 carbon atoms. Examples of such ethoxylated alcohols include the condensation product of myristyl alcohol condensed with about 10 moles of ethylene oxide per mole of alcohol; and the condensation product of about 9 moles of ethylene oxide with coconut alcohol (a mixture of fatty alcohols with alkyl chains varying in length from 10 to 14 carbon atoms). Examples of commercially available nonionic surfactants of this type include Tergitol 15-S-9, marketed by Union Carbide Corporation, Neodol 45-9, Neodol 23-6.5, Neodol 45-7, and Neodol 45-4, marketed by Shell Chemical Company, and Kyro EOB, marketed by The Procter & Gamble Company.

3. The condensation products of ethylene oxide with a hydrophobic base formed by the condensation of propylene oxide with propylene glycol. The hydrophobic portion of these compounds has a molecular weight of from 1500 to 1800 and exhibits water insolubility. The addition of polyoxyethylene moieties to this hydrophobic portion tends to increase the water solubility of the molecule as a whole, and the liquid character of the product is retained up to the point where the polyoxyethylene content is about 50% of the total weight of the condensation product, which corresponds to condensation with up to 40 moles of ethylene oxide. Examples of compounds of this type include certain of the commercially available Pluronic surfactants, marketed by Wyandotte Chemical Corporation.

4. The condensation products of ethylene oxide with the product resulting from the reaction of propylene oxide and ethylenediamine. The hydrophobic moiety of these products consists of the reaction product of ethylenediamine and excess propylene oxide, the moiety having a molecular weight of from 2500 to 3000. This hydrophobic moiety is condensed with ethylene oxide to the extent that the condensation product contains from 40% to 80% by weight of polyoxyethylene and has a molecular weight of from 5,000 to 11,000. Examples of this type of nonionic surfactant include certain of the commercially available Tetronic compounds, marketed by Wyandotte Chemical Corporation.

5. Semi-polar nonionic detergent surfactants which include water-soluble amine oxides containing one alkyl moiety of from 10 to 18 carbon atoms and 2 moieties selected from the group consisting of alkyl groups and hydroxyalkyl groups containing from 1 to 3 carbon atoms; water-soluble phosphine oxides containing one alkyl moiety of from 10 to 18 carbon atoms and 2 moieties selected from the group consisting of alkyl groups and hydroxyalkyl groups containing from 1 to 3 carbon atoms; and water-soluble sulfoxides containing one alkyl moiety of from 10 to 18 carbon atoms and a moiety selected from the group consisting of alkyl and hydroxyalkyl moieties of from 1 to 3 carbon atoms.

Preferred semi-polar nonionic detergent surfactants are the amine oxide detergent surfactants having the formula

$$R^3(OR^4)_x\overset{\overset{\displaystyle O}{\uparrow}}{N}R^5_2$$

wherein R^3 is an alkyl, hydroxyalkyl, or alkyl phenyl group or mixtures thereof containing from 8 to 22 carbon atoms; R^4 is an alkylene or hydroxyalkylene group containing from 2 to 3 carbon atoms or mixtures thereof; x is from 0 to 3; and each R^5 is an alkyl or hydroxyalkyl group containing from 1 to 3 carbon atoms or a polyethylene oxide group containing from one to 3 ethylene oxide groups. The R^5 groups can be attached to each other, e.g., through an oxygen or nitrogen atom to form a ring structure.

Preferred amine oxide detergent surfactants are C_{10}-C_{18} alkyl dimethyl amine oxide and C_8-C_{12} alkoxy ethyl dihydroxy ethyl amine oxide.

6. Alkylpolysaccharides disclosed in European Patent Application 70,074 to Ramon A. Llenado, published January 19, 1983, having a hydrophobic group containing from 6 to 30 carbon atoms, preferably from 10 to 16 carbon atoms and a polysaccharide, e.g., a polyglycoside, hydrophilic group containing from $1\frac{1}{2}$ to 10, preferably from $1\frac{1}{2}$ to 3, most preferably from 1.6 to 2.7 saccharide units. Any reducing saccharide containing 5 or 6 carbon atoms can be used, e.g. glucose, galactose and galactosyl moieties can be substituted for the glucosyl moieties. (Optionally the hydrophobic group is attached at the 2, 3, 4, etc. positions thus giving a glucose or galactose as opposed to a glucoside or galactoside.) The intersaccharide bonds can be, e.g., between the one position of the additional saccharide units and the 2-, 3-, 4-, and/or 6 positions on the preceding saccharide units.

Optionally, and less desirably, there can be a polyalkyleneoxide chain joining the hydrophobic moiety and the polysaccharide moiety. The preferred alkyleneoxide is ethylene oxide. Typical hydrophobic groups include alkyl groups, either saturated or unsaturated, branched or unbranched containing from 8 to 18, preferably from 10 to 16, carbon atoms. Preferably, the alkyl group is a straight chain saturated alkyl group. The alkyl group can contain up to 3 hydroxy groups and/or the polyalkyleneoxide chain can contain up to 10, preferably less than 5, most preferably 0, alkyleneoxide moieties. Suitable alkyl polysaccharides are octyl, nonyldecyl, undecyldodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, and octadecyl, di-, tri-, tetra-, penta-, and hexaglucosides, galactosides, lactosides, glucoses, fructosides, fructoses, and/or galactoses. Suitable mixtures include coconut alkyl, di-, tri-, tetra-, and pentaglucosides and tallow alkyl tetra-, penta-, and hexaglucosides.

The preferred alkylpolyglycosides have the formula

$R^2O(C_nH_{2n}O)_t(\text{glycosyl})_x$

wherein R^2 is selected from the group consisting of alkyl, alkylphenyl, hydroxyalkyl, hydroxyalkylphenyl, and mixtures thereof in which the alkyl groups contain from 10 to 18, preferably from 12 to 14, carbon atoms; n is 2 or 3, preferably 2; t is from 0 to 10, preferably 0; and x is from $1\frac{1}{2}$ to 10, preferably from $1\frac{1}{2}$ to 3, most preferably from 1.6 to 2.7. The glycosyl is preferably derived from glucose. To prepare these compounds, the alcohol or alkylpolyethoxy alcohol is formed first and then reacted with glucose, or a source of glucose, to form the glucoside (attachment at the 1-position). The additional glycosyl units can then be attached between their 1-position and the preceding glycosyl units 2-, 3-, 4- and/or 6- position, preferably predominately the 2-position.

7. Fatty acid amide detergent surfactants having the formula:

$$R^6-\overset{\overset{\displaystyle O}{\|}}{C}-NR^7_2$$

wherein R^6 is an alkyl group containing from 7 to 21 (preferably from 9 to 17) carbon atoms and each R^7 is selected from the group consisting of hydrogen, C_1-C_4 alkyl, C_1-C_4 hydroxyalkyl, and $-(C_2H_4O)_xH$ where x varies from 1 to 3.

Preferred amides are C_8-C_{20} ammonia amides, monoethanolamides, diethanolamides, and isopropanol amides.

B. Anionic Surfactants

Anionic surfactants suitable in detergent compositions of the present invention are generally disclosed in U.S.-A- 3,929,678 to Laughlin et al., issued December 30, 1975 at column 23, line 58 through column 29, line 23.

Classes of anionic surfactants included are:

1. Ordinary alkali metal soaps such as the sodium, potassium, ammonium and alkylolammonium salts of higher fatty acids containing from 8 to 24 carbon atoms, preferably from 10 to 20 carbon atoms.

2. Water-soluble salts, preferably the alkali metal, ammonium and alkylolammonium salts, of organic sulfuric reaction products having in their molecular structure an alkyl group containing from 10 to 20 carbon atoms and a sulfonic acid or sulfuric acid ester group. (Included in the term "alkyl" is the alkyl portion of acyl groups.)

Examples of this group of anionic surfactants are the sodium and potassium alkyl sulfates, especially those obtained by sulfating the higher alcohols (C_8-C_{18} carbon atoms) such as those produced by reducing the glycerides of tallow or coconut oil; and the sodium and potassium alkylbenzene sulfonates in which the alkyl group contains from 9 to 15 carbon atoms, in straight chain or branched chain configuration, e.g., those of the type described in U.S.-A- 2,220,099 and 2,477,383. Especially valuable are linear straight chain alkylbenzene sulfonates in which the average number of carbon atoms in the alkyl group is from 11 to 13, abbreviated as C_{11}-C_{13}LAS.

Preferred anionic surfactants of this type are the alkyl polyethoxylate sulfates, particularly those in which the alkyl group contains from 10 to 22, preferably from 12 to 18 carbon atoms, and wherein the polyethoxylate chain contains from 1 to 15 ethoxylate moieties preferably from 1 to 3 ethoxylate moieties. These anionic detergent surfactants are particularly desirable for formulating heavy-duty liquid

laundry detergent compositions.

Other anionic surfactants of this type include sodium alkyl glyceryl ether sulfonates, especially those ethers of higher alcohols derived from tallow and coconut oil; sodium coconut oil fatty acid monoglyceride sulfonates and sulfates; sodium or potassium salts of alkyl phenol ethylene oxide ether sulfates containing from 1 to 10 units of ethylene oxide per molecule and wherein the alkyl groups contain from 8 to 12 carbon atoms; and sodium or potassium salts of alkyl ethylene oxide ether sulfates containing 1 to 10 units of ethylene oxide per molecule and wherein the alkyl group contains from 10 to 20 carbon atoms.

Also included are water-soluble salts of esters of alphasulfonated fatty acids containing from 6 to 20 carbon atoms in the fatty acid group and from 1 to 10 carbon atoms in the ester group; water-soluble salts of 2-acyloxy-alkane-1-sulfonic acids containing from 2 to 9 carbon atoms in the acyl group and from 9 to 23 carbon atoms in the alkane moiety; alkyl ether sulfates containing from 10 to 20 carbon atoms in the alkyl group and from 1 to 30 moles of ethylene oxide; water-soluble salts of olefin sulfonates containing from 12 to 24 carbon atoms; and beta-alkyloxy alkane sulfonates containing from 1 to 3 carbon atoms in the alkyl group and from 8 to 20 carbon atoms in the alkane moiety.

3. Anionic phosphate surfactants.

4. N-alkyl substituted succinamates.

C. Ampholytic Surfactants

Ampholytic surfactants can be broadly described as aliphatic derivatives of secondary or tertiary amines, or aliphatic derivatives of heterocyclic secondary and tertiary amines in which the aliphatic radical can be straight chain or branched and wherein one of the aliphatic substituents contains from 8 to 18 carbon atoms and at least one contains an anionic water-solubilizing group, e.g. carboxy, sulfonate, sulfate. See U.S.-A-3,929,678 to Laughlin et al., issued December 30, 1975 at column 19, lines 18-35 for examples of ampholytic surfactants.

D. Zwitterionic Surfactants

Zwitterionic surfactants can be broadly described as derivatives of secondary and tertiary amines, derivatives of heterocyclic secondary and tertiary amines, or derivatives of quaternary ammonium,quaternary phosphonium or tertiary sulfonium compounds. See U.S.-A- 3,929,678 to Laughlin et al., issued December 30, 1975 at column 19, line 38 through column 22, line 48 for examples of zwitterionic surfactants.

E. Cationic Surfactants

Cationic surfactants can also be included in detergent compositions of the present invention. Suitable cationic surfactants include the quaternary ammonium surfactants having the formula:

$$[R^2(OR^3)_y][R^4(OR^3)_y]_2R^5N^+X^-$$

wherein R^2 is an alkyl or alkyl benzyl group having from 8 to 18 carbon atoms in the alkyl chain; each R^3 is selected from the group consisting of $-CH_2CH_2-$, $-CH_2CH(CH_3)-$, $-CH_2CH(CH_2OH)-$, $-CH_2CH_2CH_2-$, and mixtures thereof; each R^4 is selected from the group consisting of C_1-C_4 alkyl, C_1-C_4 hydroxyalkyl, benzyl, ring structures formed by joining the two R^4 groups, $-CH_2CHOHCHOHCOR^6CHOHCH_2OH$ wherein R^6 is any hexose or hexose polymer having a molecular weight less than 1000, and hydrogen when y is not 0; R^5 is the same as R^4 or is an alkyl chain wherein the total number of carbon atoms of R^2 plus R^5 is not more than 18; each y is from 0 to 10 and the sum of the y values is from 0 to 15; and X is any compatible anion.

Preferred of the above are the alkyl quaternary ammonium surfactants, especially the mono-long chain alkyl surfactants described in the above formula when R^5 is selected from the same groups as R^4. The most preferred quaternary ammonium surfactants are the chloride, bromide and methylsulfate C_8-C_{16} alkyl trimethylammonium salts, C_8-C_{16} alkyl di(hydroxyethyl)methylammonium salts, the C_8-C_{16} alkyl hydroxyethyldimethylammonium salts, and C_8-C_{16} alkyloxypropyl trimethylammonium salts. Of the above, decyl trimethylammonium methylsulfate, lauryl trimethylammonium chloride, myristyl trimethylammonium bromide and coconut trimethylammonium chloride and methylsulfate are particularly preferred.

Other useful cationic surfactants are disclosed in U.S.-A-4,259,217 to Murphy, issued March 31, 1981,.

Detergent Builders

Detergent compositions of the present invention can optionally comprise inorganic or organic detergent builders to assist in mineral hardness control. When included, these builders typically comprise up to 60% by weight of the detergent composition. Built liquid formulations preferably comprise from 1 to 25% by weight detergent builder, most preferably from 3 to 20% by weight, while built granular formulations preferably comprise from 5 to 50% by weight detergent builder, most preferably from 10 to 30% by weight.

Suitable detergent builders include crystalline aluminosilicate ion exchange materials having the formula:

$$Na_z[(AlO_2)_z \cdot (SiO_2)_y \cdot xH_2O$$

wherein z and y are at least 6, the mole ratio of z to y is from 1.0 to 0.5; and x is from 10 to 264. Amorphous hydrated aluminosilicate materials useful herein have the empirical formula

$$M_z(zAlO_2 \cdot ySiO_2)$$

wherein M is sodium, potassium, ammonium or substituted ammonium, z is from 0.5 to about 2; and y is 1; this material having a magnesium ion exchange capacity of at least 50 milligram equivalents of $CaCO_3$ hardness per gram of anhydrous aluminosilicate.

The aluminosilicate ion exchange builder materials are in hydrated form and contain from 10% to 28% of water by weight if crystalline, and potentially even higher amounts of water if amorphous. Highly preferred crystalline aluminosilicate ion exchange materials contain from 18% to 22% water in their crystal matrix. The preferred crystalline aluminosilicate ion exchange materials are further characterized by a particle size diameter of from 0.1 micrometer to 10 micrometers. Amorphous materials are often smaller, e.g., down to less than 0.01 micrometer. More preferred ion exchange materials have a particle size diameter of from 0.2 micrometer to 4 micrometers. The term "particle size diameter" represents the average particle size diameter of a given ion exchange material as determined by conventional analytical techniques such as, for example, microscopic determination utilizing a scanning electron microscope. The crystalline aluminosilicate ion exchange materials are usually further characterized by their calcium ion exchange capacity, which is at least 200 mg. equivalent of $CaCO_3$ water hardness/g. of aluminosilicate, calculated on an anhydrous basis, and which generally is in the range of from 300 mg. eq./g. to 352 mg. eq./g. The aluminosilicate ion exchange materials are still further characterized by their calcium ion exchange rate which is at least 8.9 x 10^{-3} gram/litre/minute/gram/litre(2 grains Ca^{++}/gallon/minute/gram/gallon) of aluminosilicate (anhydrous basis), and generally lies within the range of from 8.9 x 10^{-3} gram/litre/minute/gram/litre (2 grains/gallon/minute/gram/gallon) to 27 x 10^{-3} gram/litre/minute/gram/litre (6 grains/gallon/minute/gram/gallon) based on calcium ion hardness. Optimum aluminosilicates for builder purposes exhibit a calcium ion exchange rate of at least (4 grains/gallon/minute/gram/gallon). 18 x 10^{-3} gram/litre/minute/gram/litre.

The amorphous aluminosilicate ion exchange materials usually have a Mg^{++} exchange capacity of at least 50 mg. eq. $CaCO_3$/g. (12 mg. Mg^{++}/g.) and a Mg^{++} exchange rate of at least about 4.5 x 10^{-3} gram/litre/minute/gram/litre (1 grain/gallon/minute/gram/gallon.) Amorphous materials do not exhibit an observable diffraction pattern when examined by Cu radiation (1.54 10^{-10}m).

Useful aluminosilicate ion exchange materials are commercially available. These aluminosilicates can be crystalline or amorphous in structure and can be naturally-occurring aluminosilicates or synthetically derived. A method for producing aluminosilicate ion exchange materials is disclosed in U.S.-A-3,985,669 to Krummel, et al. issued October 12, 1976. Preferred synthetic crystalline aluminosilicate ion exchange materials useful herein are available under the designations Zeolite A, Zeolite P (B), and Zeolite X. In an especially preferred embodiment, the crystalline aluminosilicate ion exchange material has the formula

$$Na_{12}[(AlO_2)_{12}(SiO_2)_{12}] \cdot xH_2O$$

wherein x is from 20 to 30, especially about 27.

Other examples of detergency builders include the various water-soluble, alkali metal, ammonium or substituted ammonium phosphates, polyphosphates, phosphonates, polyphosphonates, carbonates, silicates, borates, polyhydroxysulfonates, polyacetates, carboxylates, and polycarboxylates. Preferred are the alkali metal, especially sodium, salts of the above.

Specific examples of inorganic phosphate builders are sodium and potassium tripolyphosphate,

pyrophosphate, polymeric metaphate having a degree of polymerization of from 6 to 21, and orthophosphate. Examples of polyphosphonate builders are the sodium and potassium salts of ethylene-1,1-diphosphonic acid, the sodium and potassium salts of ethane 1-hydroxy-1,1-diphosphonic acid and the sodium and potassium salts of ethane, 1,1,2-triphosphonic acid. Other phosphorus builder compounds are disclosed in U.S.-A- 3,159,581; 3,213,030; 3,422,021; 3,422,137; 3,400,176 and 3,400,148.

Examples of nonphosphorus, inorganic builders are sodium and potassium carbonate, bicarbonate, sesquicarbonate, tetraborate decahydrate, and silicate having a mole ratio of SiO_2 to alkali metal oxide of from 0.5 to 4.0, preferably from 1.0 to 2.4.

Useful water-soluble, nonphosphorus organic builders include the various alkali metal, ammonium and substituted ammonium polyacetates, carboxylates, polycarboxylates and polyhydroxysulfonates. Examples of polyacetate and polycarboxylate builders are the sodium, potassium, lithium, ammonium and substituted ammonium salts of ethylenediamine tetraacetic acid, nitrilotriacetic acid, oxydisuccinic acid, mellitic acid, benzene polycarboxylic acids, citric acid, and 2-hydroxyethyl ethylenediamine triacetic acid.

Highly preferred polycarboxylate builders are disclosed in U.S.-A- No. 3,308,067 to Diehl, issued March 7, 1967. Such materials include the water-soluble salts of homo- and copolymers of aliphatic carboxylic acids such as maleic acid, itaconic acid, mesaconic acid, fumaric acid, aconitic acid, citraconic acid and methylenemalonic acid.

Other builders include the carboxylated carbohydrates disclosed in U.S.-A- 3,723,322 to Diehl, issued March 28, 1973.

Other useful builders are sodium and potassium carboxymethyloxymalonate, carboxymethyloxysuccinate, cis-cyclohexanehexacarboxylate, cis-cyclopentanetetracarboxylate phloroglucinol trisulfonate, water-soluble polyacrylates (having molecular weights of from 2,000 to 200,000 for example), and the copolymers of maleic anhydride with vinyl methyl ether or ethylene.

Other suitable polycarboxylates are the polyacetal carboxylates disclosed in U.S.-A- 4,144,226, to Crutchfield et al. issued March 13, 1979, and U.S.-A- 4,246,495, to Crutchfield et al., issued March 27, 1979. These polyacetal carboxylates can be prepared by bringing together under polymerization conditions an ester of glyoxylic acid and a polymerization initiator. The resulting polyacetal carboxylate ester is then attached to chemically stable end groups to stabilize the polyacetal carboxylate against rapid depolymerization in alkaline solution, converted to the corresponding salt, and added to a surfactant.

Clay Soil Removal/Anti-Redeposition Agents

Laundry detergent compositions of the present invention desirably include a clay soil removal and/or anti-redeposition agent. These clay soil removal/anti-redeposition agents are usually included at from t 0.1 to 10% by weight of the composition. In terms of the benefits achieved, preferred detergent compositions can comprise from 0.5 to 5% by weight of these agents. Typically, these preferred compositions comprise from 1 to 3% by weight of these agents.

One group of preferred clay soil removal/anti-redeposition agents are the ethoxylated amines disclosed in European patent application 112,593 to James M. Vander Meer, published July 4, 1984. These ethoxylated amines are selected from the group consisting of:

(1) ethoxylated monoamines having the formula:

$$(X - L -)- N - (R^2)_2$$

(2) ethoxylated diamines having the formula:

$$R^2 - \underset{\underset{X}{|}}{\underset{L}{\underset{|}{N}}} - R^1 - \underset{\underset{X}{|}}{\underset{L}{\underset{|}{N}}} - R^2 \qquad (R^2)_2 - N - R^1 - \underset{\underset{X}{|}}{\underset{L}{\underset{|}{N}}} - (R^2)_2$$

or

$$(X\text{-}L\text{-})_2\text{-}\ N - R^1 - N - (R^2)_2$$

(3) ethoxylated polyamines having the formula:

$$R^3 - [(A^1)_q-(R^4)_t-\underset{}{\overset{R^2}{\overset{|}{N}}}-L-X]_p$$

(4) ethoxylated amine polymers having the general formula:

$$[(R^2)_2-N-]_w- -[-R^1-\underset{|}{N}-]-_x -[-R^1-\underset{\underset{\underset{X}{|}}{\underset{L}{|}}}{N}-]-_y -[-R^1-\overset{R^2}{\overset{|}{N}}-L-X)_z$$

and (5) mixtures thereof; wherein A^1 is

$$-\underset{\underset{R}{|}}{N}\overset{\overset{O}{\|}}{C}-,\ -\underset{\underset{R}{|}}{N}\overset{\overset{O}{\|}}{C}O-,\ -\underset{\underset{R}{|}}{N}\overset{\overset{O}{\|}}{C}\underset{\underset{R}{|}}{N}-,$$

$$-\overset{\overset{O}{\|}}{C}\underset{\underset{R}{|}}{N}-,\ -O\overset{\overset{O}{\|}}{C}\underset{\underset{R}{|}}{N}-,\ -\overset{\overset{O}{\|}}{C}O-,\ -O\overset{\overset{O}{\|}}{C}O-,\ -O\overset{\overset{O}{\|}}{C}-,\ -\overset{\overset{O}{\|}}{C}\underset{\underset{R}{|}}{N}\overset{\overset{O}{\|}}{C}-,\ \text{or } -O-;$$

R is H or C_1-C_4 alkyl or hydroxyalkyl; R^1 is C_2-C_{12} alkylene, hydroxyalkylene, alkenylene, arylene or alkarylene, or a C_2-C_3 oxyalkylene moiety having from 2 to 20 oxyalkylene units provided that no O-N bonds are formed ; each R^2 is C_1-C_4 alkyl or hydroxyalkyl, the moiety -L-X, or two R^2 together form the moiety $-(CH_2)_r-A^2-(CH_2)_s-$, wherein A^2 is -O- or $-CH_2-$, r is 1 or 2, s is 1 or 2, and r + s is 3 or 4; X is a nonionic group, an anionic group or mixture thereof; R^3 is a substituted C_3-C_{12} alkyl, hydroxyalkyl, alkenyl, aryl , or alkaryl group having p substitution sites; R^4 is C_1-C_{12} alkylene, hydroxyalkylene, alkenylene, arylene or alkarylene, or a C_2-C_3 oxyalkylene moiety having from 2 to 20 oxyalkylene units provided that no O-O or O-N bonds are formed; L is a hydrophilic chain which contains the polyoxyalkylene moiety $\{(R^5O)_m(CH_2CH_2O)_n\}$, wherein R^5 is C_3-C_4 alkylene or hydroxyalkylene and m and n are numbers such that the moiety $-(CH_2CH_2O)-$ comprises at least 50% by weight of said polyoxyalkylene moiety; for said monoamines, m is from 0 to 4, and n is at least 12; for said diamines, m is from 0 to 3, and n is at least 6 when R^1 is C_2-C_3 alkylene, hydroxyalkylene, or alkenylene, and at least 3 when R^1 is other than C_2-C_3 alkylene, hydroxyalkylene or alkenylene; for said polyamines and amine polymers, m is from 0 to 10 and n is at least 3; p is from 3 to 8; q is 1 or 0; t is 1 or 0, provided that t is 1 when q is 1; w is 1 or 0; x + y + z is at least 2; and y + z is at least 2.

Another group of preferred clay soil removal/anti-redeposition agents are the cationic compounds disclosed in European patent application 111,965 to Young S. Oh and Eugene P. Gosselink, published June 27, 1984. These cationic compounds are selected from the group consisting of:

(1) ethoxylated cationic monoamines having the formula:

$$R^2 - \underset{\underset{R^2}{|}}{\overset{\overset{R^2}{|}}{N^+}} - L - X$$

(2) ethoxylated cationic diamines having the formula:

$$X-L-\underset{\underset{X}{|}}{\underset{L}{\underset{|}{\overset{\overset{(R^3)_{d_1}}{|}}{M^1}}}}-R^1-\underset{\underset{X}{|}}{\underset{L}{\underset{|}{\overset{\overset{R^3}{|}}{N^+}}}}-L-X \qquad R^3-\underset{\underset{X}{|}}{\underset{L}{\underset{|}{\overset{\overset{(R^3)_{d_1}}{|}}{M^1}}}}-\underset{\underset{X}{|}}{\underset{L}{\underset{|}{R^1}}}-\underset{\underset{X}{|}}{\underset{L}{\underset{|}{\overset{\overset{R^3}{|}}{N^+}}}}-R^3$$

or

$$(X-L-)_2-\overset{\overset{(R^3)_{d_1}}{|}}{M^2}-R^1-\underset{\underset{R^2}{|}}{\overset{\overset{(R^3)_{d_2}}{|}}{M^2}}-R^2$$

wherein M^1 is an N^+ or N group; each M^2 is an N^+ or N group, and at least one M^2 is an N^+ group;

(3) ethoxylated cationic polyamines having the formula:

$$R^4-[(A^1)_q-(R^5)_t-\underset{\underset{R^2}{|}}{\overset{\overset{(R^3)_d}{|}}{M^2}}-L-X]_p$$

(4) ethoxylated cationic polymers which comprise a polymer backbone, at least 2 M groups and at least one L-X group, wherein M is a cationic group attached to or integral with the backbone and contains an N^+ positively charged center; and L connects groups M and X or connects group X to the polymer backbone; and

(5) mixtures thereof;

wherein A^1 is

$$-\underset{\underset{R}{|}}{N}\overset{\overset{O}{\|}}{C}-,\ -\underset{\underset{R}{|}}{N}\overset{\overset{O}{\|}}{C}O-,\ -\underset{\underset{R}{|}}{N}\overset{\overset{O}{\|}}{C}\underset{\underset{R}{|}}{N}-,\ -\overset{\overset{O}{\|}}{C}\underset{\underset{R}{|}}{N}-,\ -O\overset{\overset{O}{\|}}{C}\underset{\underset{R}{|}}{N}-,\ -\overset{\overset{O}{\|}}{C}O-,\ -O\overset{\overset{O}{\|}}{C}O-,$$

$$-O\overset{\overset{O}{\|}}{C}-,\ -\overset{\overset{O}{\|}}{C}\underset{\underset{R}{|}}{N}\overset{\overset{O}{\|}}{C}-$$

or -O-, R is H or C_1-C_4 alkyl or hydroxyalkyl, R^1 is C_2-C_{12} alkylene, hydroxyalkylene, alkenylene, arylene or alkarylene, or a C_2-C_3 oxyalkylene moiety having from 2 to 20 oxyalkylene units provided that no O-N bonds are formed; each R^2 is C_1-C_4 alkyl or hydroxyalkyl, the moiety -L-X or two R^2 together form the moiety $-(CH_2)_r-A^2-(CH_2)_s-$, wherein A^2 is -O- or $-CH_2-$, r is 1 or 2, s is 1 or 2 and r + s is 3 or 4; each R^3 is C_1-C_8 alkyl or hydroxyalkyl, benzyl, the moiety -L-X, or two R^3 or one R^2 and one R^3 together form the moiety $-(CH_2)_r-A^2-(CH_2)_s-$; R^4 is a substituted C_3-C_{12} alkyl, hydroxyalkyl, alkenyl, aryl or alkaryl group having p substitution sites; R^5 is C_1-C_{12} alkylene, hydroxyalkylene, alkenylene, arylene or alkarylene, or a C_2-C_3 oxyalkylenemoiety having from 2 to 20 oxyalkylene units provided that no O-O or O-N bonds are formed; X is a nonionic group selected from the group consisting of H, C_1-C_4 alkyl or hydroxyalkyl ester or ether groups, and mixtures thereof; L is a hydrophilic chain which contains the polyoxyalkylene moiety $\{(R^6O)_m(CH_2CH_2O)_n\}$; wherein R^6 is C_3-C_4 alkylene or hydroxyalkylene and m and n are numbers such that the moiety $-(CH_2CH_2O)-$ comprises at least 50% by weight of said polyoxyalkylene moiety; d is 1 when M^2 is N^+ and is 0 when M^2 is N; n is at least 12 for said cationic monoamines, is at least 6 for said cationic diamines and is at least 3 for said cationic polyamines and cationic polymers; p is from 3 to 8; q is 1 or 0; and t is 1 or 0, provided that t is 1 when q is 1.

Other clay soil removal/anti-redeposition agents which can be used include the ethoxylated amine polymers disclosed in European patent application 111,984 to Eugene P. Gosselink, published June 27, 1984; the zwitterionic compounds disclosed in European patent application 111,976 to Donn N. Rubingh and Eugene P. Gosselink, published June 27, 1984; the zwitterionic polymers disclosed in European patent application 112,592 to Eugene P. Gosselink, published July 4, 1984; and the amine oxides disclosed in U.S.-A-4.548.744, to Daniel S. Connor, published on October 22, 1985,

Other Optional Detergent Ingredients

Other optional ingredients which can be included in detergent compositions of the present invention, in their conventional art-established levels for use (i.e., from 0 to 20%), include solvents, bleaching agents, bleach activators, other soil-suspending agents, corrosion inhibitors, dyes, fillers, optical brighteners, germicides, pH adjusting agents (monoethanolamine, sodium carbonate, sodium hydroxide, etc.), enzymes, enzyme-stabilizing agents, perfumes, fabric softening components and static control agents.

General Detergent Formulations

Except for the previously described enrobing of the soil release compound, granular formulations embodying the detergent compositions of the present invention can be formed by conventional techniques, i.e., by slurrying the individual components in water and then atomizing and spray-drying the resultant mixture, or by pan or drum granulation of the ingredients. Granular formulations preferably comprise from 10 to 30% detergent surfactant, usually anionic, and most preferably 15 to 25% surfactant.

Liquid formulations embodying the detergent compositions can be built or unbuilt. If unbuilt, these compositions conventionally contain approximately 15 to 50% (preferably 20 to 35%) total surfactant, from 0 to 5% (preferably from 0 to 2%) of an organic base such as a mono-, di-, or tri-alkanol amine, a neutralization system such as an alkali metal hydroxide and a lower primary alcohol such as ethanol or isopropanol, and approximately 20 to 80% water.

Built liquid detergent compositions can be in the form of single phase liquids provided that the builder is solubilized in the mixture at its level of use. Such liquids conventionally contain 10 to 40% (preferably 15 to 25%) total surfactant, 1 to 25% (preferably 3 to 20%) builder which can be organic or inorganic, up to 10% of a hydrotrope system, and 20 to 80% water. Built liquid detergents incorporating components that form heterogeneous mixtures (or levels of builder that cannot be completely dissolved) can also comprise detergent compositions of the present invention. Such liquids conventionally employ viscosity modifiers to produce systems having plastic shear characteristics to maintain stable dispersions and to prevent phase separation or solid settlement. Care should also be taken to avoid exposing the soil release compounds to highly alkaline environments, e.g. those above a pH of about 8.5, during processing of the liquid detergent formulation.

A description of some prefered detergent formulations is as follows:

A. Near Neutral Wash pH Detergent Formulations

While the detergent compositions of the present invention are operative within a wide range of wash pHs, they are particularly suitable when formulated to provide a near neutral wash pH, i.e. an initial pH of from about 6.0 to about 8.5 at a concentration of from 0.1 to 2% by weight in water at 20°C. Near neutral wash pH formulations are better for enzyme stability and for preventing stains from setting. The near neutral pH of such formulations is also desirable to insure long term activity for the soil release compounds, especially those having shorter backbones. In such formulations, the product pH is preferably from 7.0 to 8.5, and more preferably from 7.5 to 8.0.

Preferred near neutral wash pH detergent formulations are disclosed in European Patent Application 95,205 to J. H. M. Wertz and P. C. E. Goffinet, published November 30, 1983,. These preferred formulations comprise:

(a) from 2 to 60% (preferably from 10 to 25%) by weight of an anionic synthetic surfactant as previously defined;

(b) from 0 to 12% (preferably from 0.5 to 4%) by weight of a cosurfactant selected from the group consisting of:

(i) quaternary ammonium surfactants having the formula:

$$[R^2(OR^3)_y][R^4(OR^3)_y]_2R^5N^+X^-$$

wherein R^2, each R^3, R^4, R^5, X and y are as previously defined;
(ii) diquaternary ammonium surfactants having the formula:

$$[R^2(OR^3)_y][R^4(OR^3)_y]_2N^+R^3N^+R^5[R^4(OR^3)_y]_2\ (X^-)_2$$

wherein R^2, R^3, R^4, y and X are as defined above; particularly preferred are the C_8-C_{16} alkyl pentamethylethylenediamine chloride, bromide and methylsulfate salts;
(iii) amine surfactants having the formula:

$$[R^2(OR^3)_y][R^4(OR^3)_y]R^5N$$

wherein R^2, R^3, R^4, R^5 and y are as defined above; particularly preferred are the C_{12}-C_{16} alkyl dimethyl amines;
(iv) diamine surfactants having the formula:

$$[R^2(OR^3)_y][R^4(OR^3)_y]NR^3NR^5[R^4(OR^3)_y]$$

wherein R^2, R^3, R^4, R^5 and y are as defined above; particularly preferred are the C_{12}-C_{16} alkyl dimethyl diamines;
(v) amine oxide surfactants having the formula:

$$[R^2(OR^3)_y][R^4(OR^3)_y]R^5N\rightarrow O$$

wherein R^2, R^3, R^4, R^5 and y are as defined above; particularly preferred are the C_{12}-C_{16} alkyldimethyl amine oxides; and
(vi) di(amine oxide) surfactants having the formula:

$$[R^2(OR^3)_y][R^4(OR^3)_y]\underset{\underset{O}{\downarrow}}{N}R^3\underset{\underset{O}{\downarrow}}{N}R^5[R^4(OR^3)_y]$$

wherein R^2, R^3, R^4, R^5 and y are as defined above; preferred are the C_{12}-C_{16} alkyl trimethylethylene di(amine oxides) and
(c) from 0 to 40% by weight (preferably 5 to 30% by weight, and most preferably from 10 to 20% by weight) of a fatty acid containing from 10 to 22 carbon atoms (preferably a C_{10}-C_{14} saturated fatty acid or mixtures thereof); the mole ratio of the anionic surfactant to the cosurfactant being at least 1 and preferably from 2:1 to 20:1.

Such compositions also preferably contain from 3 to 15% by weight of an ethoxylated alcohol or ethoxylated alkyl phenol (nonionic surfactants) as previously defined. Highly preferred compositions of this type also preferably contain from 2 to 10% by weight (preferably from 3 to 8% by weight) of a water-soluble polycarboxylate builder (preferably citric acid) and minor amounts (e.g., less than 20% by weight) of neutralizing agents, buffering agents, phase regulants, hydrotropes, enzymes, enzyme stabilizing agents, polyacids, suds regulants, opacifiers, antioxidants, bactericides, dyes, perfumes and brighteners, such as those described in U.S.-A-4,285,841 to Barrat et al., issued August 25, 1981.

B. Detergent Formulations Containing Certain Anionic Surfactants

When high levels of certain anionic detergent surfactants are used, the compounds of the present invention may not deposit as well on the fabric during laundering. See U.S.-A- 4,116,885 to Derstadt et al., issued September 26, 1978, which describes the incompatibility of ethylene terphthalate/PEG terephthalate soil release polyesters with certain anionic detergent surfactants. These anionic surfactants include the alkyl sulfates and particularly the alkyl benzene sulfonates. Inclusion of certain detergent builders such sodium tripolyphosphonate, alkali metal carbonates and aluminosilicate ion exchange materials in such anionic detergent formulations further reduces the soil release activity of the compounds.

This decreased performance can be offset by inclusion of higher levels of nonionic detergent surfactant, i.e. above 50% by weight of the surfactant system. However, higher levels of nonionic surfactants do not

provide as good cleaning as anionic surfactants, especially in granular detergent formulations. Accordingly, inclusion of a small amount (e.g. from 0.5 to 2% by weight of the total composition) of a cationic detergent surfactant(s) as previously described can be used to improve the soil release performance of the compounds. Also, soil release performance can be boosted by simply including more of the compounds of the present invention.

Soil Release Performance Testing of Polyester Compositions

A. Test Method

In testing the soil release performance of the polyester compositions, the following test method was used:

Polyester double knit (polyester) and 50%/50% polycotton t-shirt material (polycotton) fabrics were used in this testing. Using a Sears Kenmore washer, the fabrics were desized by washing with a liquid detergent composition containing the following ingredients:

Ingredients	Amount %
C_{14}-C_{15} alkyl ethoxy sulfuric acid	12.0
C_{13} linear alkylbenzene sulfonic acid	8.0
C_{12}-C_{13} alcohol poly-ethoxylate (6.5)	5.0
C_{12} alkyltrimethyl ammonium chloride	0.6
Coconut fatty acid	11.0
Citric acid monohydrate	4.0
Other and water*	Balance

* pH adjusted to 8.3 with NaOH, KOH and mono-ethanolamine.

The washing was conducted in 0.45 g (7 grain) hardness water at a temperature of 95° F (35° C) for 12 minutes, with subsequent rinsing in 0.45 g (7 grain) hardness water at a temperature of 70° F (21.1° C). This desizing step was done twice.

The desized fabrics were formed into swatches (28 cm square for the polyester fabrics, 7.6 x 28 cm (3 x 11 in.) for the polycotton fabrics). These desized swatches were then preconditioned with a detergent composition containing the above ingredients in conjunction with a solution or dispersion containing 1 to 100 ppm (wash concentration) of a soil release polyester composition. This preconditioning step was conducted in a 5 pot Automatic Mini-Washer (AMW). After the AMW pots were filled with 6 liters of water each, the detergent composition, and the solution/dispersion of soil release polyester composition, were added to each pot. Test swatches were then added to each of the filled pots. The wash cycle was conducted in 0.45 g (7 grain) hardness water at a temperature of 95° F (35° C) for 12 minutes. After the wash cycle, there was a 2-minute spin cycle, followed by a 2-minute rinse cycle using 0.45 g (7 grain) hardness water at a temperature of 80° F (26.7° C).

Union Guardol 76 SAE 30 detergent clean motor oil colored with 0.075% red EGN dye was used to soil these preconditioned swatches. For the preconditioned polyester swatches, 100 10^{-6} ℓ of this soil was placed on 3 separate spots. Similarly, for the preconditioned polycotton swatches, 50 10^{-6} ℓ. of this soil was placed on 3 different spots. The stained swatches were placed on racks and allowed to wick for at least 16 hours.

The soiled swatches were then washed in the AMW with the above detergent composition (without addition of the soil release polyester composition) using the same wash, spin and rinse cycle conditions as in the preconditioning step. After the rinse cycle, the test swatches were dried in a mini-dryer. Gardner

Whiteness meter readings (L, a and b) were then determined for each test swatch. Soil release performance in terms of Hunter Whiteness Values (W) was then calculated according to the following equation:

$$W = \frac{7L^2 - 40\ Lb}{700}$$

The higher the value for W, the better the soil release performance.

B. Test Results

In summarizing test results, the polyester compositions are identified by: (1) the average number of monomer units in the backbone of the polyesters; and (2) the number of methyl capped PEGs at the end of the polyester backbone. The following nomenclature is used to identify the monomer units and methyl capped PEGs:

T = terephthalate
EG = ethylene glycol
PG = 1,2-propylene glycol
MeE_n = methyl capped PEG, n being the average number of ethoxy units ($-CH_2CH_2O-$) in the PEG

For example, 2.75 T, 1.75 EG, 2 MeE_{16} represents a polyester composition where the polyesters have an average of 2.75 terephthalate units, 1.75 ethylene glycol units and two methyl capped PEGs, the PEG having an average 16 ethoxy units.

1. Efficiency of Propylene Glycol Based Polyesters

The soil release performance of a 2.75 T, 1.75 PG, 2 MeE_{16} polyester composition was tested at different levels. In this testing, aqueous solutions of the polyester composition were added during the preconditioning step. The results are shown in Table I:

Table I

Level (ppm)*	W Values	
	Polyester	Polycotton
10	23.7 ± 1.4	31.3 ± 0.6
15	47.5 ± 3.7	37.5 ± 0.4
20	54.4 ± 1.0	41.1 ± 0.6
30	60.2 ± 2.9	39.9 ± 1.8

* wash concentration of polyester composition

2. Efficiency of Ethylene Glycol Based Polyesters

The soil release performance of a 2.75 T, 1.75 EG, 2 MeE_{16} polyester composition was tested at different levels. In this testing, phenoxyethanol solutions of the polyester composition were added during the preconditioning step. The results are shown in Table II:

Table II

Level (ppm)*	W Values	
	Polyester	Polycotton
1	3.7 ± 0.1	6.8 ± 0.7
2	6.7 ± 0.1	12.2 ± 0.5
3	19.8 ± 2.7	28.5 ± 0.9
4	40.2 ± 1.4	35.8 ± 1.1
5	51.3 ± 1.2	39.6 ± 1.7

* wash concentration of polyester composition

3. Variations in Polyester Backbone and Methyl Capped PEGs

The soil release performance of polyester compositions having different polyester backbones and different methyl capped PEGs at the end of the polyester backbone was tested. In this testing, aqueous dispersions (10 ppm wash concentration) of the polyester compositions were added during the preconditioning step. The results are shown in Table III:

Table III

Polyester Composition	W Values	
	Polyester	Polycotton
None	3.2 ± 0.1	4.0 ± 0.9
2.75 T, 1.75 EG, 2 MeE_{16}	49.9 ± 0.9	39.6 ± 2.1
1.5 T, 0.5 EG, 2 MeE_{43}	6.0 ± 0.6	20.1 ± 1.2
2 T, 1.0 EG, 2 $MeE_{7.5}$	18.8 ± 3.0	18.5 ± 2.6
2.6 T, 1.6 EG, 2 MeE_{12}	49.1 ± 1.7	38.0 ± 1.8

4. Number of Terephthalate Units in Polyester Backbone

The soil release performance of ethylene glycol based polyester compositions having different average numbers of terephthalate units in the polyester backbone were tested. In this testing, aqueous dispersions (10 ppm wash concentration) were added during the preconditioning step. The results are shown in Table IV.

Table IV

Polyester Composition	W Values	
	Polyester	Polycotton
2.0 T, 1.0 EG, 2 MeE_{16}	2.9 ± 0.3	6.3 ± 1.4
2.8 T, 1.8 EG, 2 MeE_{16}	5.2 ± 0.3	16.6 ± 1.8
4.0 T, 3.0 EG, 2 MeE_{16}	49.8 ± 1.5	46.3 ± 1.5
5.4 T, 4.4 EG, 2 MeE_{16}	63.3 ± 1.4	48.0 ± 0.8
8.8 T, 7.8 EG, 2 MeE_{16}	55.4 ± 1.4	43.6 ± 1.9

5. Comparison of Block Polyesters to Milease T[R]

The soil release performance of block polyester compositions of the present invention (2.75 T, 1.75 EG.

2 MeE_{16}) were compared to a Milease T^R polyester composition. In this comparison, phenoxyethanol solutions of the polyester compositions were added during the preconditioning step. The results are shown in Table V:

Table V

	Level (ppm)*	SRP Values	
		Polyester	Polycotton
Block polyester	5	53.3 ± 2.7	38.7 ± 1.7
Milease T	5	6.8 ± 2.1	31.6 ± 1.1
Block polyester	10	63.4 ± 1.2	38.4 ± 1.5
Milease T	10	49.1 ± 10.8	39.8 ± 2.2

* wash concentration of polyester composition

Specific Embodiments of Detergent Compositions According to the Present Invention

Embodiment I

The following embodiments illustrate, but are not limiting of, detergent compositions of the present invention:

A granular detergent composition is as follows:

Component	Wt. %
Polyester of Example 1 *	2.0
Sodium C_{14}-C_{15} alkylethoxysulfate	10.7
C_{13} linear alkyl benzene sulfonic acid	4.3
C_{12}-C_{14} alkylpolyethoxylate (6)	0.5
C_{12} alkyltrimethyl ammonium chloride	0.5
Sodium toluene sulfonate	1.0
Sodium tripolyphosphate	32.9
Sodium carbonate	20.3
Sodium silicate	5.8
Minors and water	Balance to 100

* Enrobed in PEG having an average M.W. 8,000.

Except for the enrobed polyester particles, the components are added together with continuous mixing to form an aqueous slurry which is then spray dried to form granules. The enrobed polyester particles are then mixed with the granules to form the composition.

Embodiment II

A liquid detergent composition is formulated as follows:

Component	Wt. %
Polyester of Example 2	1.0
$PEA_{189}E_{17}$ *	1.0
Sodium C_{12} alkylethoxy (1) sulfate	9.4
C_{12}-C_{13} alcohol polyethoxylate (6.5)	21.5
Ethanol	7.5
Sodium diethylenetriamine pentaacetate	0.2
MAXATASE	0.026 Anson units/g
TERMAMYL	0.51 KNu/g
Sodium formate	1.6
Calcium formate	0.1
Minors and water	Balance to 100

* Polyethyleneamine having M.W. of 189 and degree of ethoxylation of 17 at each reactive hydrogen.

The components are added together with continuous mixing to form the composition.

Embodiments III and IV

Liquid detergent compositions are as follows:

Component	Wt. % III	Wt. % IV
Polyester of Example 1 *	1.0	1.0
$PEA_{189}E_{17}$	2.0	1.5
C_{14}-C_{15} alkylpolyethoxy (2.25) sulfuric acid	12.0	10.8
C_{13} linear alkylbenzene sulfonic acid	8.0	8.0
C_{12} alkyl trimethylammonium chloride	0.6	1.2
C_{12}-C_{13} alcohol polyethoxylate (6.5)	5.0	6.5
Coconut fatty acid	10.0	13.0
Oleic acid	-	2.0
Citric acid monohydrate	4.0	4.0
Diethylenetriamine pentaacetic acid	0.2	0.2
Protease enzyme	0.8	0.8
Amylase enzyme	0.2	0.2
Monoethanolamine	2.0	2.0
Sodium hydroxide	2.4	1.7
Potassium hydroxide	1.1	2.7
1,2-Propanediol	3.5	7.3
Ethanol	8.5	7.8
Formic acid	0.08	0.7
Boric acid	1.3	
Calcium ion	0.03	0.03
Minors and water	Balance to 100	

* Made with 1,2-propylene glycol instead of ethylene glycol

Embodiment III is prepared by adding the components together with continuous mixing, in the following order to produce a clear liquid: a paste premix of alkylbenzene sulfonic acid, a portion of the sodium hydroxide, propylene glycol, and a portion of the ethanol; a paste premix of alkylpolyethoxysulfuric acid, a portion of the sodium hydroxide and a portion of the ethanol; pentaacetic acid; a portion of the alcohol polyethoxylate; a premix of water, triethanolamine, brighteners and the remainder of the alcohol polyethoxylate; the remaining ethanol; potassium hydroxide and the remaining sodium hydroxide; citric acid; fatty acid; formic acid, boric acid and calcium; alkyl trimethylammonium chloride; $PEA_{189}E_{17}$ (50% aqueous solution); polyester of Example 1; adjust to pH 8.0; and balance of components. Embodiment IV can be prepared in a similar manner.

Claims

1. Polyester of formula :

$$X-(OCH_2CH_2)_n-[-(\overset{O}{\overset{\|}{C}}O-R^1-\overset{O}{\overset{\|}{C}}O-R^2)_u-]-O\overset{O}{\overset{\|}{C}}-R^1-\overset{O}{\overset{\|}{C}}O-(CH_2CH_2O)_n-X$$

wherein each R^1 moiety is a 1,4-phenylene moiety; the R^2 moieties are essentially ethylene moieties, 1,2-propylene moieties or mixtures thereof; each X is ethyl or methyl; each n is from 12 to 43; u is from 3 to 10.

2. The polyesters of Claim 1, wherein said R^2 moieties comprise from 80 to 100% of said ethylene moieties, 1,2-propylene moieties, or mixtures thereof.

3. The polyesters of claims 1 or 2, wherein each X is methyl

4. A detergent composition which comprises :
   (a) from 1 to 75% by weight of a nonionic, anionic, ampholytic, zwitterionic, or cationic detergent surfactant, or mixture thereof; and
   (b) a soil release component which comprises an effective amount of a soil release compound according to claim 1.

5. The composition of Claim 4 which comprises from 0.1 to 10% by weight of the soil release compound.

6. The composition of Claims 4 or 5, which is an isotropic liquid.

7. The composition of Claims 4, 5, or 6 which comprises from 10 to 50% by weight of said detergent surfactant.

Revendications

1. Polyester de formule:

$$X-(OCH_2CH_2)_n-[-(O\overset{O}{\overset{\|}{C}}-R^1-\overset{O}{\overset{\|}{C}}O-R^2)_u-]-O\overset{O}{\overset{\|}{C}}-R^1-\overset{O}{\overset{\|}{C}}O-(CH_2CH_2O)_n-X$$

dans laquelle chaque radical R^1 est un radical 1,4-phénylène; les radicaux R^2 sont essentiellement des radicaux éthylène, 1,2-propylène ou des mélanges de ceux-ci; chaque radical X est le groupe éthyle ou méthyle; chaque n va de 12 à 43; u va de 3 à 10.

2. Polyester selon la revendication 1, dans lequel lesdits radicaux R^2 comprennent de 80 à 100 % desdits radicaux éthylène, 1,2-propylène ou de mélanges de ceux-ci.

3. Polyester selon la revendication 1 ou 2, dans lequel chaque X est le groupe méthyle.

4. Composition de détergent comprenant:
   (a) de 1 à 75 % en poids d'un agent tensioactif détergent non ionique, anionique, ampholyte, amphotère ou cationique, ou d'un mélange de ceux-ci; et
   (b) un composant d'élimination des salissures qui comprend une quantité efficace d'un composé d'élimination des salissures selon la revendication 1.

5. Composition selon la revendication 4, comprenant de 0,1 à 10 % en poids du composé d'élimination des salissures.

6. Composition selon la revendication 4 ou 5, qui est un liquide isotrope.

7. Composition selon la revendication 4, 5 ou 6, comprenant de 10 à 50 % en poids dudit agent tensioactif détergent.

Patentansprüche

1. Polyester der Formel:

$$X-(OCH_2CH_2)_n-[-(O\overset{O}{\overset{\|}{C}}-R^1-\overset{O}{\overset{\|}{C}}O-R^2)_u-]-$$

$$-O\overset{O}{\overset{\|}{C}}-R^1-\overset{O}{\overset{\|}{C}}O-(CH_2CH_2O)_n-X\ ,$$

worin jeder R^1-Rest ein 1,4-Phenylenrest ist; die R^2-Reste im wesentlichen Ethylenreste, 1,2-Propylenreste oder Gemische hievon sind; jedes X für Ethyl oder Methyl steht; jedes n von 12 bis 43 beträgt; u von 3 bis 10 beträgt.

2. Polyester nach Anspruch 1, worin die genannten R^2-Reste 80 bis 100 % der genannten Ethylenreste, 1,2-Propylenreste oder Gemische hievon umfassen.

3. Polyester nach Anspruch 1 oder 2, worin jedes X für Methyl steht.

4. Detergenszusammensetzung, welche:
   (a) 1 bis 75 Gew.-% eines nichtionischen, anionischen, ampholytischen, zwitterionischen oder kationischen grenzflächenaktiven Detergensmittels oder von eine Gemisch hievon ; und
   (b) eine Schmutzlösekomponente umfaßt, welche eine wirksame Menge einer Schmutzlöseverbindung nach Anspruch 1 enthält.

5. Zusammensetzung nach Anspruch 4, welche 0,1 bis 10 Gew.-% der Schmutzlöseverbindung umfaßt.

6. Zusammensetzung nach Anspruch 4 oder 5, welche eine isotrope Flüssigkeit ist.

7. Zusammensetzung nach den Ansprüchen 4, 5 oder 6, welche 10 bis 50 Gew.-% des genannten grenzflächenaktiven Detergensmittels umfaßt.

Fig. 1

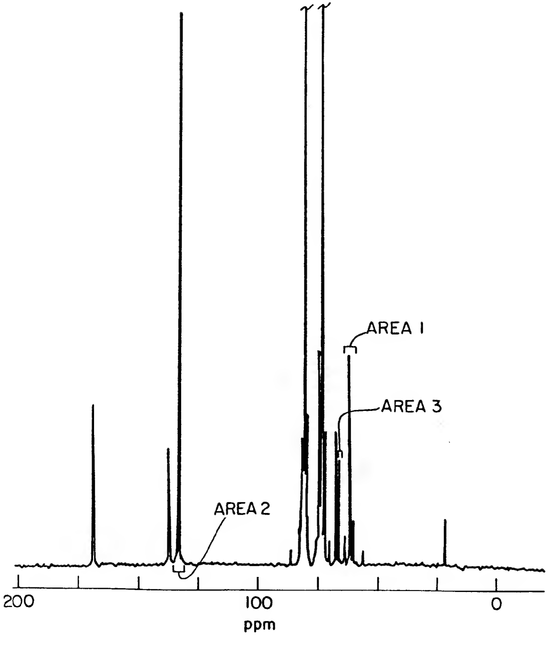


Fig. 2